CIRCUITS AND METHODS PROVIDING TEMPERATURE MITIGATION FOR COMPUTING DEVICES USING ESTIMATED SKIN TEMPERATURE

TECHNICAL FIELD

[0001] This application relates to thermal mitigation and, more specifically, to providing thermal mitigation to a computing device by estimating a device skin temperature.

BACKGROUND

[0002] A conventional modern smart phone may include a system on chip (SOC), which has a processor and other operational circuits. Specifically, an SOC in a smart phone may include a processor chip within a package, where the package is mounted on a printed circuit board (PCB) internally to the phone. The phone includes an external housing and a display, such as a liquid crystal display (LCD). A human user when using the phone physically touches the external housing and the display.

[0003] As the SOC operates, it generates heat. In one example, the SOC within a smart phone may reach temperatures of 80° C.-100° C. Furthermore, conventional smart phones do not include fans to dissipate heat. During use, such as when a human user is watching a video on a smart phone, the SOC generates heat, and the heat is spread through the internal portions of the phone to the outside surface of the phone.

[0004] The outside surface of the phone is sometimes referred to as the "skin." The outside surface includes the part of the external housing that is physically on the outside of the phone as well as any other externally-exposed portions, such as an LCD display. It is generally accepted that the skin of the phone should not reach temperatures higher than about 40° C.-45° C. due to safety and ergonomic reasons. As noted above, the SOC within the smart phone may reach temperatures of 80° C.-100° C., although the temperature of the SOC is not felt directly at the skin of the phone. Instead, heat dissipation within the phone often means that the skin temperature of the phone is at a lower temperature than the SOC temperature. Furthermore, whereas changes to SOC temperature may be relatively quick (e.g., seconds), changes to device skin temperature may be relatively slow (e.g., tens of seconds or minutes).

[0005] Conventional smart phones include algorithms to control the skin temperature by reducing a frequency of operation of the SOC when a temperature sensor in the SOC reaches a threshold level. However, SOC temperature can be a poor proxy for device skin temperature.

SUMMARY

[0006] Various embodiments include systems and methods that mitigate temperature by measuring temperature within the computing device, estimating an external surface temperature of the device, and reducing performance of a processor, if appropriate, based at least in part on the temperature estimate.

[0007] In one embodiment, a method for mitigating temperature of a device includes receiving a signal from a temperature sensor, wherein the temperature sensor is disposed within the device having a processor chip that produces heat within the device. The method also includes generating temperature data from the signal and processing the temperature data to generate data indicative of a temperature of an external surface of the device. Processing the temperature data includes applying a low pass filter, an amplitude attenuation, and a delay to the digital temperature data. The method also includes reducing an operating parameter of the processor chip in response to the data indicative of the temperature of the external surface.

[0008] In another embodiment, a computer program product having a computer readable medium tangibly recording computer program logic for mitigating temperature of a device includes: code to receive a signal from a temperature sensor, wherein the temperature sensor is disposed within the device having a processor chip that produces heat within the device, code to generate temperature data from the signal, code to apply a low pass filter, an amplitude attenuation, and a delay to the temperature data to generate data indicative of a temperature of an external surface of the device; and code to reduce an operating parameter of the processor chip in response to the data indicative of the temperature of the external surface of the device.

[0009] In another embodiment, a system for mitigating temperature includes a processor, a housing configured to enclose at least a portion of the system, the processor being disposed within the system so that it is enclosed within the housing and being in indirect thermal contact with the housing. The system also includes a temperature sensing device disposed within the housing and being in electrical communication with the processor. The processor is configured to perform the following operation: generate first temperature data indicative of a temperature experienced by the temperature sensing device; estimate a temperature of an external surface of the housing by generating second temperature data, wherein generating second temperature data includes applying a transfer function to the first temperature data, the transfer function including a low pass filter, amplitude attenuation, and delay; and reduce an operating parameter of the processor in response to the second temperature data.

[0010] In yet another embodiment, a method for temperature mitigation includes receiving temperature data of an internal component of an enclosed computing device, estimating a temperature of an external surface of the computing device by applying attenuation, filtering, and delay to the temperature data of the internal component. The method further includes comparing an estimation of the temperature of the external surface of the computing device to a programmed threshold, wherein the program threshold corresponds to a temperature limit of the external surface of the computing device, reducing an operating parameter of the computer processor of the computing device in response to the comparing, and subsequently increasing the operating parameter of the computer processor in response to determining that the estimation of the temperature of the external surface of the computing device has decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is an illustration of an example computing device that may perform a method according to various embodiments.

[0012] FIG. **2** is an illustration of the internal functional units of the computing device of FIG. **1**, according to one embodiment.

[0013] FIG. **3** is an illustration of thermal management circuitry and logic, according to one embodiment.